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on March 16, 2001,
by Saundra S. Christopher Saundra S. Christopher

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: A. Benayoun et al.

Serial No.: 09/755,687

Filed: January 5, 2001

For: Method and System for Dynamically Inverting an Asymmetric Digital Subscriber Line (ADSL) System

To: Assistant Commissioner of Patents
Washington, DC 20231

TRANSMITTAL OF PRIORITY DOCUMENT
(UNDER 35 USC 119)

Sir:

Enclosed herewith is certified copy of European Application number 00480014.0 filed on January 6, 2000.

Respectfully submitted,

Reg. No.: 42,682
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Fax No. 919-254-4330

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Europäisches Patentamt | European Patent Office | Office européen des brevets

Bescheinigung | Certificate | Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

00480014.0

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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I.L.C. HATTEN-HECKMAN

DEN HAAG, DEN
THE HAGUE, 30/03/00
LA HAYE, LE

Europäisches Patentamt
European Patent Office
Office européen des brevets

Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.:
Demande n°: 00480014.0

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Anmelder:
Applicant(s):
Demandeur(s):
International Business Machines Corporation
Armonk, N.Y. 10504
UNITED STATES OF AMERICA

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Method for dynamically inverting an asymmetric digital subscriber line (ADSL) system and system for implementing it

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

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Internationale Patentklassifikation:
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Bemerkungen:
Remarks:
Remarques:

METHOD FOR DYNAMICALLY INVERTING AN ASYMMETRIC DIGITAL SUBSCRIBER LINE (ADSL) SYSTEM AND SYSTEM FOR IMPLEMENTING IT.

Technical field

The present invention relates to the Asymmetric Digital Subscriber Line (ADSL) connections established between an access node of service provider network such as the Internet network and a user workstation, and relates in particular to a method for dynamically inverting an ADSL system and system for implementing it.

Background

Modems are used to enable two computers to communicate by using the Public Switched Telephone Network (PSTN). The latter carries only analog signals so that modems are used to translate the digital data from a computer into a series of high-pitched signals which can be transported over the phone lines. When such analog signals arrive at the destination, they are demodulated into digital data for the receiving computer.

Now, a new type of modems, Digital Subscriber Line (DSL) modems create a digital subscriber line, but the network remains the same PSTN network. A DSL modem transmits duplex data at higher speed than conventional modems. Such modems use a twisted pair bandwidth from 0 to approximately 80 kHz which preludes the simultaneous use of analog telephone service in most cases.

Asymmetric Digital Subscriber Line (ADSL), a new modem technology, belongs to this DSL family and converts existing twisted-pair telephone lines into access paths for multimedia and high speed data communications. ADSL transmits more than 6 Mbps to a subscriber or user premises, and as much as 640 kbps in the reverse direction. Such rates expand existing access capacity by a factor of 50 or more without new cabling. ADSL can transform the existing public information network from one limited to voice, text and low resolution graphics to a powerful, ubiquitous system capable of bringing multimedia, including full motion video, to everyone's home this century.

The ADSL system will play an important role over the next ten or more years as telephone companies enter new markets for delivering information in video and multimedia formats. New broad band cabling will take decades to reach all prospective subscribers. But success of these new services will depend upon reaching as many subscribers as possible during the first few years. By bringing movies, television, video catalogs, remote CD-ROMs, corporate LANs, and the Internet into homes and small businesses, ADSL will make these markets viable, and profitable, for telephone companies and application suppliers alike.

Many applications foreseen for ADSL involve digital compressed video. As a real time signal, digital video cannot use link or network level error control procedures commonly found in data communications systems. ADSL modems therefore incorporate

forward error correction that dramatically reduces errors caused by impulse noise. Error correction on a symbol by symbol basis also reduces errors caused by continuous noise coupled into a line.

In an ADSL system, there is an ADSL modem on each end of a twisted-pair telephone line, creating three information channels ; a high speed downstream channel, a medium speed duplex channel, depending on the implementation of the ADSL architecture, and a POTS (Plain Old Telephone Service) or an ISDN channel. The POTS/ISDN channel is split off from the digital modem by filters, thus guaranteeing uninterrupted POTS/ISDN, even if ADSL fails. The high speed channel ranges from 1.5 to 6.1 Mbps, while duplex rates range from 16 to 640 kbps.

The minimum configuration provides 1.5 or 2.0 Mbps downstream and a 16 kbps duplex channel. ADSL modems will accommodate ATM transport with variable rates and compensation for ATM overhead, as well as IP protocols. Downstream data rates depend on a number of factors, including the length of the copper line, its wire gauge, presence of bridged taps, and cross-coupled interference. Line attenuation increases with line length and frequency, and decreases as wire diameter increases.

Each ADSL channel can be submultiplexed into multiple lower rate channels. To create multiple channels, ADSL modems divide the available bandwidth of a telephone line in one of two ways, Frequency Division Multiplexing (FDM) or Echo Cancellation. FDM assigns one band for upstream data and another band for downstream data. The downstream path is then divided by time division multiplexing into one or more high speed channels and one or more low speed channels. The upstream path is also multiplexed into corresponding low speed channels. Echo Cancellation assigns the upstream band to

overlap the downstream, and separates the two by means of local echo cancellation, a technique well known in V.32 and V.34 modems. With either technique, ADSL splits off a 4 kHz region for POTS at the DC end of the band.

However, being asymmetric, the ADSL system does not enable to use the overall bandwidth for some applications wherein the user workstation acts as a server for the transmission of large files, a video conferencing or a data distribution. In other words, a today ADSL system is always asymmetric and fits only applications requiring high speed transmission in one direction only.

Summary of the invention

Accordingly, the object of the invention is a method for dynamically inverting an Asymmetric Digital Subscriber Line (ADSL) system, enabling the user workstation, which normally transmits data only over the medium speed channel, to transmit data over the high speed channel if necessary.

The invention relates therefore to a method for dynamically inverting an Asymmetric Digital Subscriber Line (ADSL) system comprising at least a central exchange equipment ADSL CE connected to a service provider network and at least a user equipment ADSL UE connected to a user workstation, both equipment being interconnected by a PSTN link. The ADSL CE is provided with an input line for transmitting high speed data from the service provider network to the user workstation and an output line for receiving medium speed data from the user workstation and also comprises CE coding/decoding means for coding the high speed data and decoding the medium speed data and the ADSL UE is provided with an input line for transmitting medium speed data from the user workstation to the service provider network and an output line for receiving high speed data from the service provider network and also

including UE coding/decoding means for coding the medium speed data and decoding the high speed data. This method comprises the following steps :

a) upon request said user workstation to transmit high speed data on the input line in the ADSL UE and receiving medium speed data on the output line in the ADSL UE, transmitting an inverting request message from the ADSL UE to the ADSL CE,

b) upon receiving the inverting request message by the ADSL CE, activating the CE coding/decoding means for coding medium speed data which will be transmitted on the input line in the ADSL CE and decoding high speed data which will be received on the output line in the ADSL CE,

c) transmitting a first acknowledgment message from the ADSL CE to the ADSL UE in order to inform this one that transmission in reverse mode is authorized,

d) upon receiving the first acknowledgment message by the ADSL UE, activating the UE coding/decoding means for coding high speed data which will be transmitted on the input line in the ADSL UE and decoding medium speed data which will be received on the output line in the ADSL CE, and

e) transmitting a second acknowledgment message from the ADSL UE to the ADSL CE in order to inform this one that switching into reverse mode is completed.

Brief description of the drawings

The above and other objects, features and advantages of the invention will be better understood by reading the following more particular description of the invention in conjunction with the accompanying drawings wherein :

- Fig. 1 is a schematic representation of an ADSL system including an ADSL central exchange equipment connected to a service provider network and an ADSL user equipment connected to a user workstation.

- Fig. 2A and 2B represent respectively a block diagram of a normal ADSL system including the central exchange equipment and the user equipment and a block diagram of the same ADSL system which has been switched into the reverse mode according the method of the invention.
- Fig. 3 is a block diagram representing an ADSL transmission unit being used in the ADSL central exchange equipment or in the ADSL user equipment and comprising means for implementing the method of the invention.
- Fig. 4 is a flow chart of the steps followed by the ADSL user equipment for implementing the method of the invention.
- Fig. 5 is a flow chart of the steps followed by the ADSL central exchange equipment for implementing the method of the invention.

Detailed description of the invention

Fig. 1 describes a communication system including a service provider WAN 10 which can be the Internet network connected to a central exchange equipment (CE) 12 by means of an access node 14. CE 12 includes an ADSL Transmission Unit ATU-C 16 and a splitter 18 which splits/merges the low bandwidth voice signals exchanged with a voice CX 20 and the modulated data on a PSTN twisted pair 22.

On the other side, the PSTN twisted pair 22 is also connected to a splitter in a user equipment (UE) 26. Splitter 24 is connected to a telephone set (POTS) to handle voice communications on the one hand and to an ADSL Transmission Unit ATU-R on the other hand. ATU-R 30 is connected to a workstation but could also be attached to a LAN such as the Ethernet network.

According to the configuration illustrated in Fig. 2A, central exchange equipment CE 12 includes ATU-C 16 and splitter 18

(connected to voice central exchange CX) and is provided with an input line 34 for inputting high speed data in the range of several Mbits/s (e.g. 6 Mbits/s) and an output line 36 for outputting medium speed data in the range of several hundred of kbits (e.g. 640 Kbits/s), both lines being connected to ATU-C 16. On the other side, user equipment UE 26 includes splitter 24 (connected to a POTS) and ATU-R 30 to which are connected an output line 38 for receiving high speed data and an input line 40 for transmitting medium speed data.

Fig. 2B shows the ADSL system of Fig. 2A which has been switched into the reverse mode according to the method of the invention. For this, in a preferred embodiment, each splitter 18 or 24 has a request R line 42 and 44 respectively on which is forwarded a tone sequence of low frequency signals which is used by ATU-C or ATU-R for dynamically inverting the system. Assuming that the user wants to transmit high speed data on input line 40, a tone sequence is forwarded on line 40. Upon detecting the tone sequence, splitter 24 and splitter 18 activate their R line 44 and 42 respectively. At this time, ATU-C 16 becomes ATU-Cr 16′ and behaves as an ATU-R while ATU-R becomes ATU-Rc 30′ and behaves as an ATU-C. ATU-Rc 30′ has now a high speed output line 40′ and a medium speed output line 38′ while ATU-Cr 16′ has now a medium speed input line 34′ and a high speed output line 36′.

An alternate method to dynamically invert the ADSL system of Fig. 2A is to build a control channel between ATU-C 16 and ATU-R 30 within the data bandwidth wherein an invert request message is transmitted. This method may be used as long as the settings on both sides match thereby allowing to extract data. In case of failure of this data channel caused by a bad synchronization of the reverse function for example, the tone sequence method may correct the failure and can be considered as a low level activation method.

Fig. 3 shows the details of an ADSL equipment including an ATU-Cr 46 and a splitter 48 according to the principles of the invention.

There are an input line 50 for inputting high speed data and an output line 52 for outputting medium speed data . But such an ADSL equipment is also used as user equipment except that the unit ATU-Cr is replaced by a unit ATU-Rc. Note that generally, a lot of channels may be defined as inputs which are multiplexed together. This is the case when a full duplex low speed channel is built using some bandwidth from the high speed downstream channel. When more bandwidth is available, more channels are defined, and when the bandwidth is reduced, some channels are suppressed.

Data coming on line 50 are put in a superframe structure by multiplexer 54. A FIFO 56 is added before multiplexer 54 to store the frames during transition when the reverse function is applied as seen hereafter. Multiplexer 54 may multiplex one or several data channels plus one control channel from processing engine 58. During the normal transmission, FIFO 56 should be empty or quite empty. Then, ADSL coding is performed by coding/decoding unit 60. Such a coding includes constellation encoding and gain scaling, modulation such as inverse Discrete Fourier Transform, output parallel or serial buffering and digital/analog conversion.

Assuming that the user workstation wants to transmit high speed data, there are two ways to invert the system. In the first way, a tone generator 62 in the user equipment generates after receiving a request CMD1 from processing engine 58, a tone sequence (low frequency signals) which is transmitted on the PSTN twisted pair via low pass filter 64. Note that low pass filter 64 is used principally to separate voice signals which are exchanged with POTS 66.

When the tone sequence is received in the central exchange equipment, it is decoded by a tone decoder 68. Tone decoder 68 sends a R1 command to inform processing engine 58 of the occurrence of the request to invert the system.

In the second way, an inverting request message is put out the superframe thanks to command CMD2 from processing engine 58 of the user equipment. Command CMD2 is then multiplexed with data by multiplexer 54 before being coded by coding/decoding unit 60 and transmitted over the PSTN twisted pair to the central exchange equipment.

When received in the central exchange equipment, the digital data (including the control channel) are first received by high pass filter 70 before being decoded by coding/decoding unit 60. Then, decoded data is supplied to demultiplexer 72 which extracts the control channel and sends its on R2 line to processing engine 58.

When processing engine 58 of the central exchange equipment receives either command R1 from tone decoder 68, or command R2 from demultiplexer 72, it sets an ACT command which is a request for activation of coding/decoding unit 60. Upon receiving such an activation, coding/decoding unit 60 performs all necessary steps to consider now that the input data on line 50 is high speed data and output data on line 52 is medium speed data.

Upon setting the ACT line, processing engine 58 either sends a command CMD1 to tone generator 62 in order to transmit a tone sequence over the PSTN twisted pair to the user equipment or sends a command CMD2 to be inserted in the control channel by multiplexer 54 in order to be transmitted with medium speed data over the PSTN Twisted pair. Whatever way is used, the message being sent is an acknowledgment to the user equipment authorizing this one for transmitting high speed data on its

input line. It must be noted that an alternate way is to replace the acknowledgement message by the superframe itself. In such a case, a line SD to the processing engine of the user equipment is set when a superframe with the medium speed is detected by demultiplexer 72 of the user equipment.

Upon receiving the acknowledgment message from the central exchange equipment, that is, either a tone sequence is detected, or a command CMD2 in control channel is decoded, or the superframe with the new medium speed is detected as already explained, the user equipment performs the step of activating its coding/decoding unit 60 as explained here above. At the same time, another acknowledgment message is transmitted to the central exchange equipment in the same way that previously when a first acknowledgment message is transmitted from the central exchange equipment to the user equipment. Note that the acknowledgment message could be replaced by the superframe itself as previously by setting the SD line from demultiplexer 72 to processing engine 58 in the central exchange equipment.

It must be noted that :

1) all the data coming on input line 40 in the user equipment are stored in FIFO 56 during the interval of time between sending the inverting request message to the central exchange and receiving the first acknowledgment message from the central exchange equipment, or during the interval of time between sending a superframe (generally empty) to the central exchange equipment and receiving a superframe from the same central exchange equipment.

2) all the data coming on input line 50 in the central exchange equipment are stored in FIFO 56 during the interval of time between sending the first acknowledgment message to the user equipment and receiving the second acknowledgment message from the user equipment, or during the interval of time between sending a superframe (generally empty) to the

user equipment and receiving a superframe from the same user equipment.

The steps of the method according to the invention with regard to the user equipment are represented in Fig. 4 . The process is first initialized when the user workstation requests to invert the ADSL system (step 74). Upon receiving such a request, the ADSL user equipment executes the three following steps as described hereabove : it sends an inverting request message to the central exchange equipment (step 76), it activates the coding/decoding unit of the user equipment to switch into the reverse mode (step 78) and it starts storing data to be transmitted in the FIFO of the user equipment (step 80). Then, it is checked whether the FIFO is full (step 82) without receiving the first acknowledgment from the CE equipment. If so, an error flag is logged (step 84). If not, it is checked whether the first acknowledgment is received whereas the FIFO is not full (step 86). If this first acknowledgment is not received, the process is looped back to the step 82 of checking whether the FIFO is full. When it is determined that the FIFO is full or that the FIFO being not full, the first acknowledgment has been received, the transmission in reverse mode is started. (step 88).

The steps of the method according to the invention with regard to the user equipment are represented in Fig. 5. The process is first initialized if the central exchange equipment receives an inverting request message from the user equipment (step 90). Upon receiving such a message, the central exchange equipment executes the following steps which have been described previously : a first acknowledgment is sent to the user equipment (step 92), the coding/decoding unit of the central exchange equipment is activated to switch into the reverse mode (step 94) and the data to be transmitted from the user equipment to the central exchange equipment are stored in the FIFO of the user equipment (step 96). Then, it is checked

whether the FIFO is full (step 98) without receiving the second acknowledgment from the central exchange equipment. If it is the case, an error flag is logged (step 100). If not, it is checked whether the second acknowledgment is received whereas the FIFO is not full (step 102). If the second acknowledgment is not received, the process is looped back to step 98 of checking whether the FIFO is full. When it is determined that, the FIFO is full or that, the FIFO being not full, the second acknowledgment has been received, the transmission in reverse mode is started (step 104).

CLAIMS

1. Method for dynamically inverting an Asymmetric Digital Subscriber Line (ADSL) system comprising at least a central exchange equipment ADSL CE (12) connected to a service provider network (10) and at least a user equipment ADSL UE (26) connected to a user workstation (32), both equipment being interconnected by a PSTN link (22), said ADSL CE being provided with an input line (34) for transmitting high speed data from said service provider network to said user workstation and an output line (36) for receiving medium speed data from said user workstation and also comprising CE coding/decoding means for coding said high speed data and decoding said medium speed data, and said ADSL UE being provided with an input line (40) for transmitting medium speed data from said user workstation to said service provider network and an output line (38) for receiving high speed data from said service provider network and also including UE coding/decoding means for coding said medium speed data and decoding said high speed data ;

said method being characterized in that it comprises the following steps :

a) upon request said user workstation to transmit high speed data on said input line in said ADSL UE and receiving medium speed data on said output line in said ADSL UE, transmitting an inverting request message from said ADSL UE to said ADSL CE,

b) upon receiving said inverting request message by said ADSL CE, activating said CE coding/decoding means for coding medium speed data which will be transmitted on said input line in said ADSL CE and decoding high speed data which will be received on said output line in said ADSL CE,

c) transmitting a first acknowledgment message from said ADSL CE to said ADSL UE in order to inform this one that transmission in reverse mode is authorized,

d) upon receiving said first acknowledgment message by said ADSL UE, activating said UE coding/decoding means for coding high speed data which will be transmitted on said input line in said ADSL UE and decoding medium speed data which will be received on said output line in said ADSL CE, and

e) transmitting a second acknowledgment message from said ADSL UE to said ADSL CE in order to inform this one that switching into reverse mode is completed.

2. Method according to claim 1, wherein said inverting request message is a tone sequence which is generated by a tone generator (62) in said ADSL UE (26) and decoded by a tone decoder (68) in said ADSL CE.

3. Method according to claim 1, wherein said inverting request message is a control message transmitted in a control channel multiplexed with data in the data superframe transmitted from said ADSL UE (26) to said ADSL CE (12).

4. Method according to any one of claims 1 to 3, wherein said first acknowledgment message is a tone sequence which is generated by a tone generator (62) in said ADSL CE (12) and decoded by a tone decoder (68) in said ADSL UE (26).

5. Method according to any one of claims 1 to 3, wherein said first acknowledgment message is either a control message transmitted in a control channel of a first superframe having the medium speed transmitted from said ADSL CE (12) to said ADSL UE (26) or said first superframe itself.

6. Method according to any one of claims 1 to 5, wherein said second acknowledgment message is a tone sequence which is

generated by a tone generator (62) in said ADSL UE (26) and decoded by a tone decoder (68) in said ADSL CE (12).

7. Method according to any one of claims 1 to 5, wherein said second acknowledgment message is either a control message transmitted in a control channel having the high speed transmitted from said ADSL UE (26) to said ADSL CE (12) or said superframe itself.

8. Method according to any one of claims 1 to 7, wherein data which are received from said user workstation (32) in said ADSL UE (26) after that said inverting request message has been sent from said ADSL UE (26) to said ADSL CE (12), are buffered in a FIFO (56) until said first acknowledgment message is received by said ADSL UE.

9. Method according to any one of claims 1 to 8, wherein the transmission in reverse mode from said ADSL UE (26) is authorized if said FIFO (56) is full before said first acknowledgment message is received by said ADSL UE.

10. Method according to any one of claims 1 to 9, wherein data which are received from said service provider network (10) in said ADSL CE (12) after that said first acknowledgment message has been sent from said ADSL CE to said ADSL UE (26), are buffered in a FIFO (56) until said second acknowledgment message is received by said ADSL CE.

11. Method according to claim 10, wherein the transmission in reverse mode from said ADSL CE (12) is authorized if said FIFO (56) is full before said second acknowledgment message is received by said ADSL CE.

12. ADSL system comprising means adapted for carrying out the steps of the method according to any one of the previous claims.

METHOD FOR DYNAMICALLY INVERTING AN ASYMMETRIC DIGITAL SUBSCRIBER LINE (ADSL) SYSTEM AND SYSTEM FOR IMPLEMENTING IT.

Abstract

Method for dynamically inverting an Asymmetric Digital Subscriber Line (ADSL) system comprising a central exchange equipment ADSL CE (12) connected to a network (10) and a user equipment ADSL UE (26) connected to a user workstation (32) interconnected by a PSTN link (22). ADSL CE (12) is provided with a high speed data input line and a medium speed data output line whereas ADSL UE (26) is provided with a medium speed data input line and an high speed data output line. This method comprises the following steps:

a) upon request of the user workstation, transmitting an inverting request message from the ADSL UE to the ADSL CE,

b) upon receiving the inverting request message, switching the ADSL CE into the reverse mode,

c) transmitting a first acknowledgment message from the ADSL CE to the ADSL UE,

d) upon receiving the first acknowledgment message, switching ADSL UE into the reverse mode, and

e) transmitting a second acknowledgment message from the ADSL UE to the ADSL CE.

FIG. 1

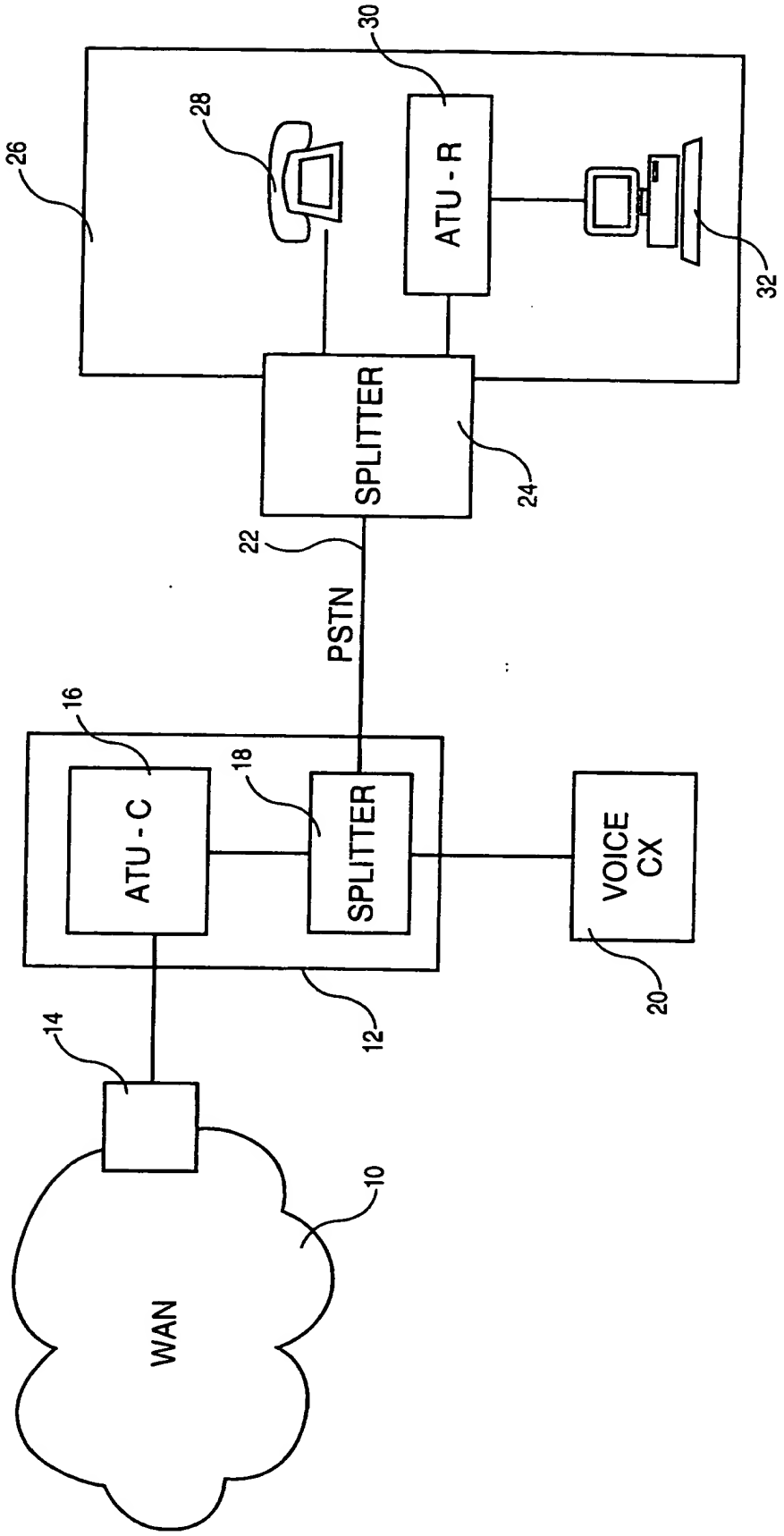
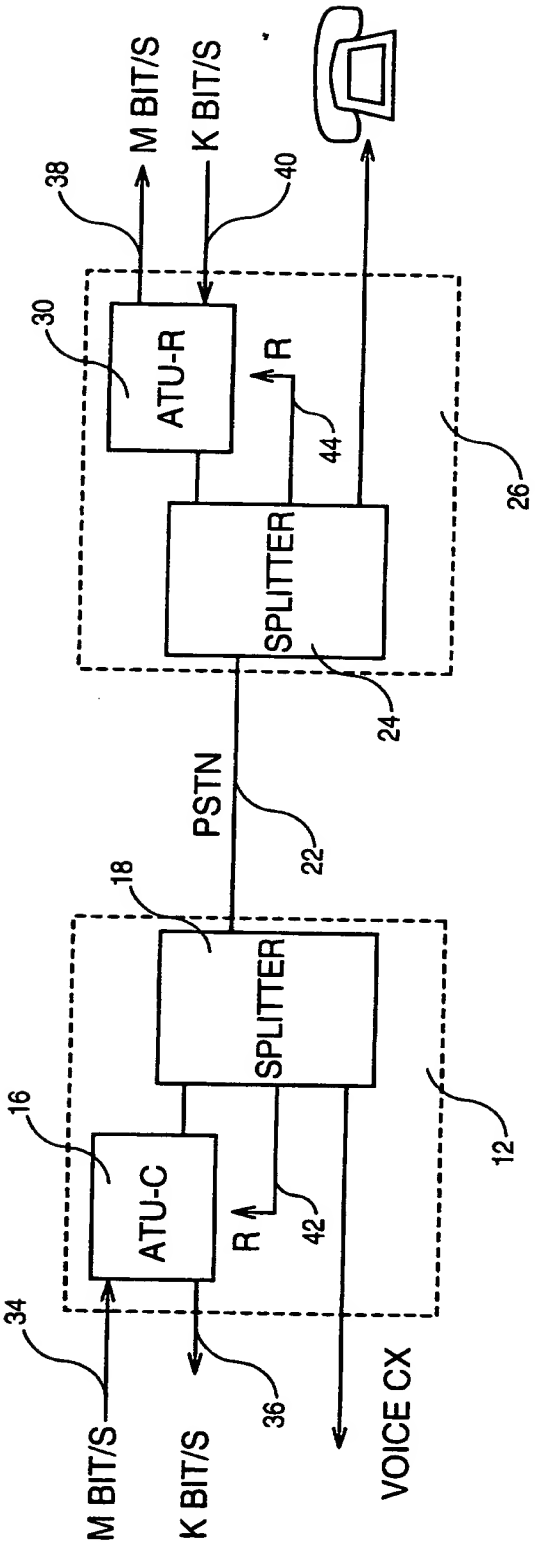

30
28
26
ATU - R
32
SPLITTER
24
22
PSTN
16
18
ATU - C
SPLITTER
VOICE CX
20
12
14
10
WAN

FIG. 1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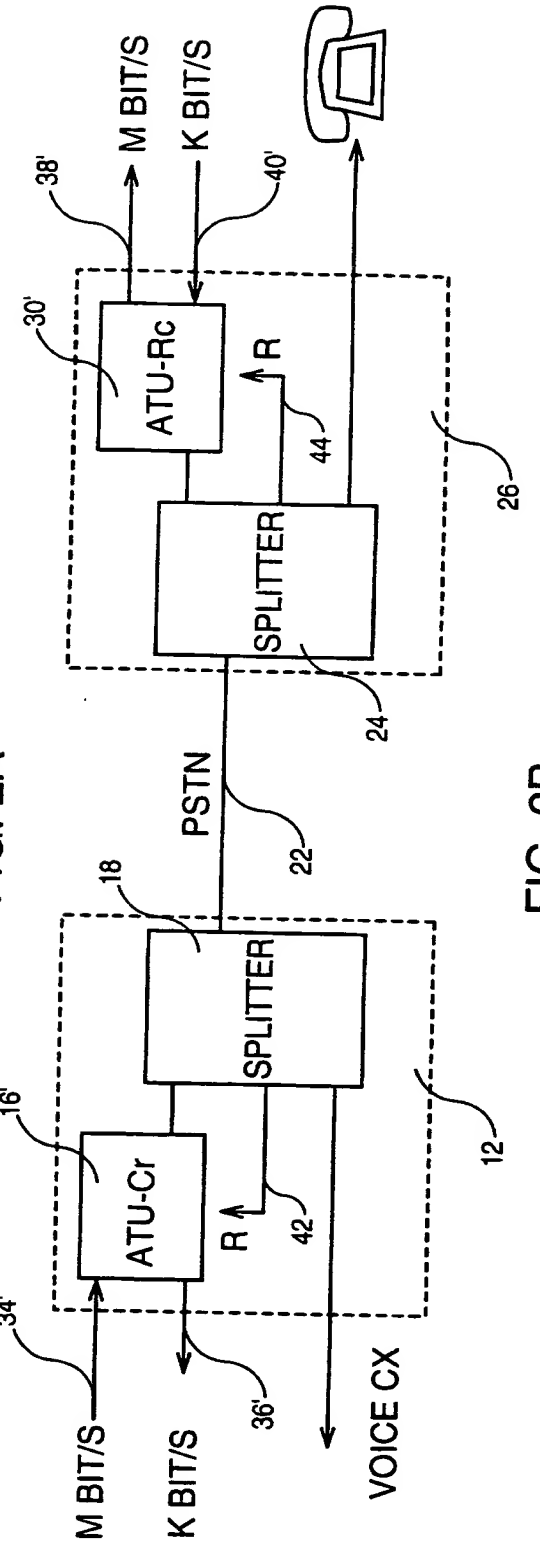
K BIT/S
38
40
30
ATU-R
R
44
SPLITTER
26
24
PSTN
22
18
SPLITTER
16
ATU-C
R
42
12
34
36
M BIT/S
K BIT/S
VOICE CX

FIG. 2A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K BIT/S
38'
40'
30'
ATU-Rc
R
44
SPLITTER
26
24
PSTN
22
18
SPLITTER
16'
ATU-Cr
R
42
12
34'
36'
M BIT/S
K BIT/S
VOICE CX

FIG. 2B

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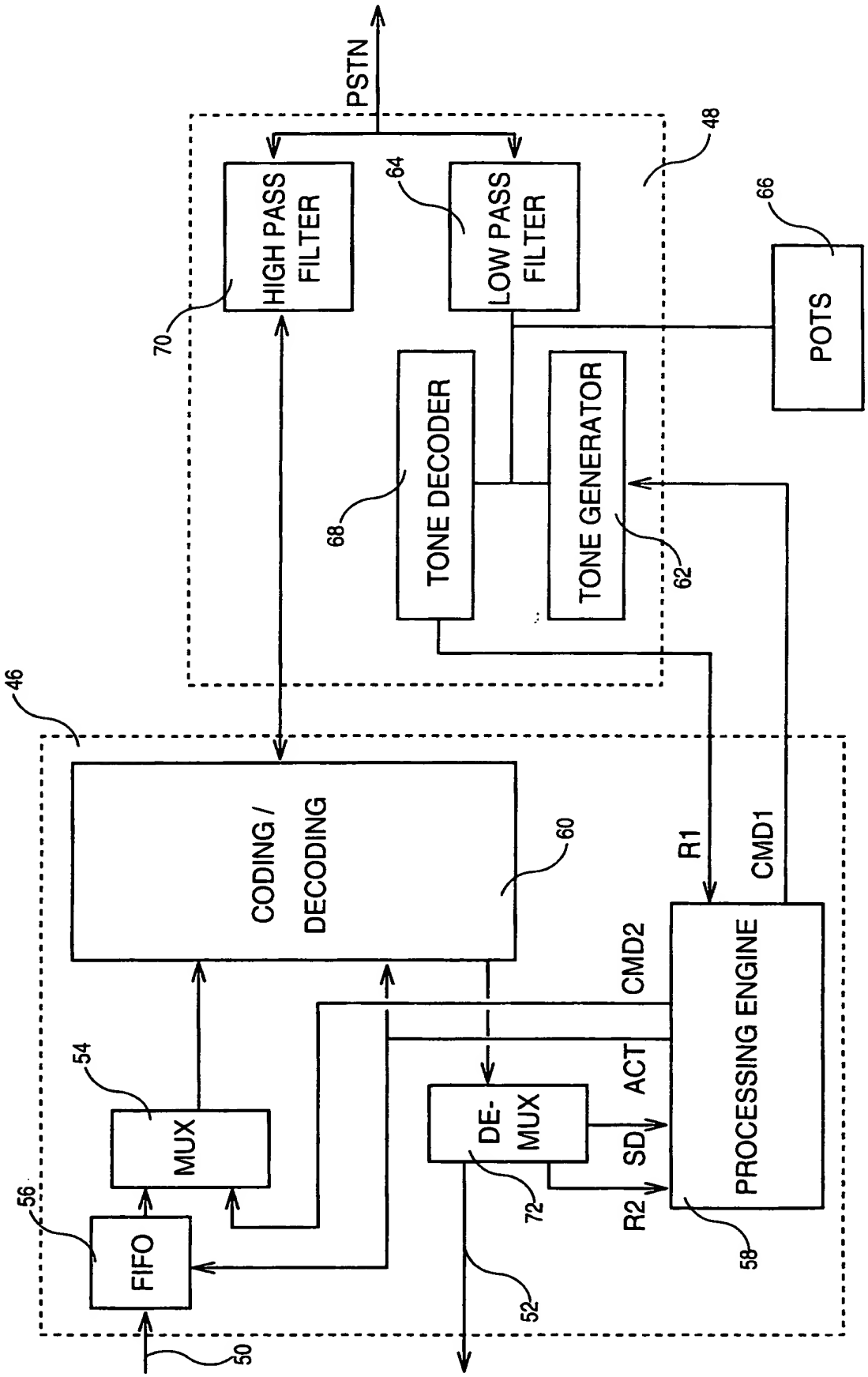

FIG. 3

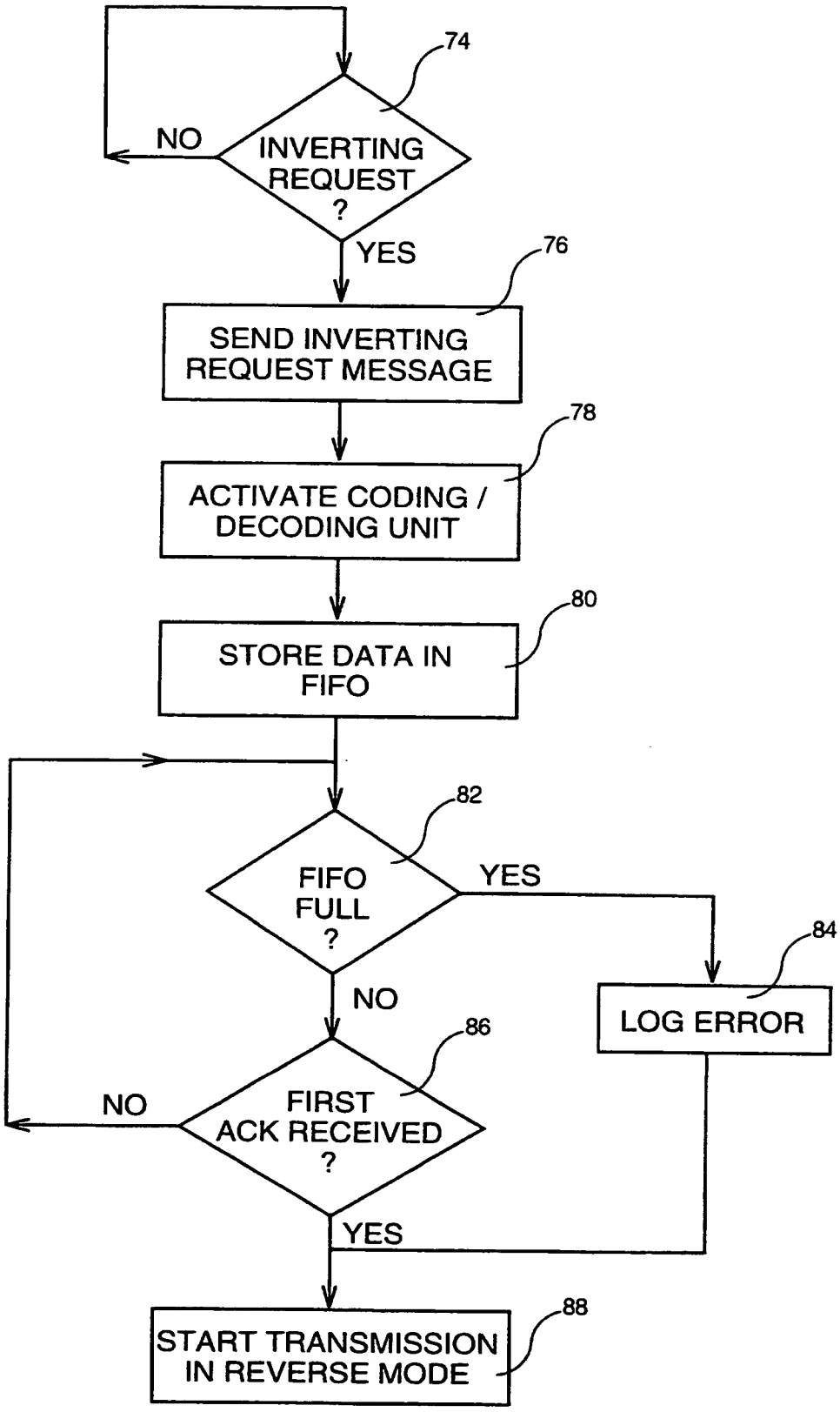
74
INVERTING REQUEST ?
NO
YES
76
SEND INVERTING REQUEST MESSAGE
78
ACTIVATE CODING / DECODING UNIT
80
STORE DATA IN FIFO
82
FIFO FULL ?
YES
84
LOG ERROR
NO
86
FIRST ACK RECEIVED ?
NO
YES
88
START TRANSMISSION IN REVERSE MODE

FIG. 4

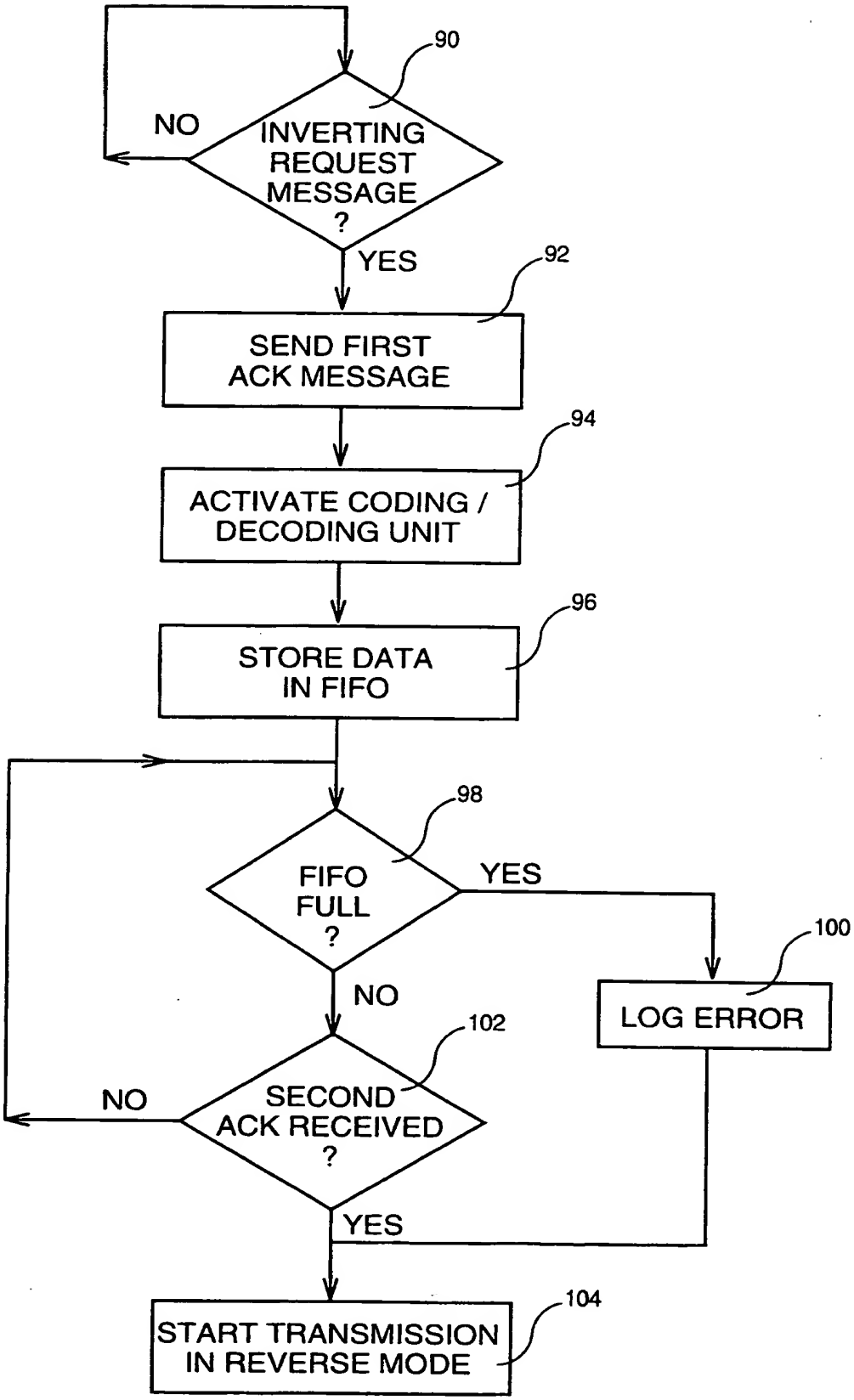
90
INVERTING REQUEST MESSAGE ?
NO
YES
92
SEND FIRST ACK MESSAGE
94
ACTIVATE CODING / DECODING UNIT
96
STORE DATA IN FIFO
98
FIFO FULL ?
YES
100
LOG ERROR
NO
102
SECOND ACK RECEIVED ?
NO
YES
104
START TRANSMISSION IN REVERSE MODE

FIG. 5